the two stations indicates a degree of relationship so slight as to be negligible. During this period the range in the monthly mean values was from 1.933 to 1.907, or 0.026 gr. cal.

On Figures 2 and 3 a cross has been located within the circles that inclose most of the dots, to show the mean value of the solar constant determinations indicated by the dots. A second cross has been located at a point to indicate the mean of solar constant values represented by the dots on the other corresponding figure. These two crosses fall on a line making an angle of very nearly 45° with the axes of ordinates and abscissas, which indicates that the results as summarized above are not inconsistent with Abbot's finding of a high correlation coefficient between the means of groups of synchronous values at Montezuma and Harqua Hala, arranged in order of magnitude of the solar constant determinations at Montezuma.[8] Such a grouping eliminates very largely the day-to-day variations discussed above; and the correlations found are the result of secular changes occurring during the period covered by the three groups, and not real correlations between actual day-to-day changes free from secular variations.

Furthermore, during the period April, 1922, to November, 1924, inclusive, a solar constant value is given on 827 days, and on 299 of these days, or on 1 day out of 2.78, values obtained at both stations were included in the mean for the day. The mean value for the whole period is 1.922. On 36 days the value was less than 1.900, and on 6 of these days, or on only 1 day out of 6, was the value derived from determinations made at both stations. On 35 days the value was 1.940 or above, and on 4 of these, or on 1 day out of 8.75, the value was derived from determinations made at both stations. Thus, while more than one third of the daily values have been derived from measurements made at both stations, this is the case with only about one seventh of the values that depart from the mean by more than ±1%.

In view of the above, and for the further reason that one out of every six of these extreme values is by Abbot graded $U+$ or U (rather unsatisfactory or unsatisfactory), they are not entitled to as much weight as the more nearly average values.

Abbot holds the view that since there are more *values with large departures* than theory calls for, this is a proof of solar variability.[9] It is not unusual to find such an excess however.[10] Further, in this particular case, it has been shown above that these extreme values have not the same degree of accuracy as the remaining values. Therefore the excess in their number, which is small numerically, can not be accepted as evidence of solar variability.

It seems evident, therefore, that the day-to-day variability of the solar constant determinations, the standard deviation of which is less than ±0.70 per cent, depends largely upon whether the solar constant value is derived from determinations made at only one or at both stations; that it reflects unavoidable inaccuracies in pyrheliometric readings, and in extrapolating the readings to zero air mass; and that short-period solar variability, if it exists, falls within the limits of the probable error of the determinations.

[8] Abbot, C. G., Solar variation and forecasting, p. 20, Smithsonian Misc. Coll., vol. 77, No. 5.

[9] Solar variability and forecasting. Smithsonian Misc. Coll., vol. 77, No. 5, pp. 16–18.

[10] Brunt, David. The combination of observations. (Cambridge, 1917) p. 33.

THE PROBABLE 24-HOUR TEMPERATURE CHANGE (7 A. M. TO 7 A. M.) AT MONTGOMERY, ALA.

By JESSE W. SMITH and WELBY R. STEVENS

[Montgomery, Ala., Weather Bureau Office, May 18, 1925]

In this study the probable temperature change for the 24-hour period 7 a. m. to 7 a. m., 90th meridian time, at Montgomery, Ala., has been determined by means of the Gram-Charlier frequency curves for each month of the year, based on 1,000 observations for each month.

The temperature changes were determined from the a. m. observations as recorded on Form No. 1001–Metl., beginning with 1924 and going back far enough to include 1,000 days in each monthly distribution. Each temperature was taken to the nearest even degree before the change was computed, thus giving the change in 2° units. This was done in order to give actual changes considered in the verification of forecasts.

The Gram-Charlier curves were selected because of the relative ease with which they may be computed and their flexibility, which promised good fits in all cases. Reference to Figure 1 shows that very good fits were obtained. It is the belief of the authors that the Gram-Charlier curves are particularly well adapted to meteorological distributions, because of their capacity to take care of both skewness and excess, which are likely to be encountered in appreciable degree, especially in monthly distributions.

It seems unnecessary to give a detailed description of the method of fitting these curves. Reference is made to Fisher,[1] where a lucid explanation may be found, both of the mathematical development and practical application. However, for practical application, tables [2] will be necessary containing the values of the generating function $\varphi_0(z)=\frac{1}{\sqrt{2\pi}}e^{-z^2:2}$ and its derivatives up to at least the fourth order.

Computations and the necessary control checks were made for each month, of which only January is shown, in Table 1, to illustrate the method.

Perhaps slightly better fits would have been obtained had the parameters been computed by the method of least squares instead of the method of semi-invariants, but the arithmetical labor entailed would have been almost prohibitive.

It is well known that in dealing with a limited series of observations the third and fourth moments, or in this case the third and fourth semi-invariants, are liable to considerable error, due to the chance presence of a few large departures. It was found in most of the calculations that this error was sufficient to cause a slowing up in the rate of increase near the tails of the curves, or in some cases enough to cause serious secondary inflections. It was found possible to eliminate this undesirable situation by neglecting, in the computation of the third and fourth semi-invariants, the observations at the tails beyond the value $z=(x-\lambda_1):\sigma>4$. Inasmuch as never more

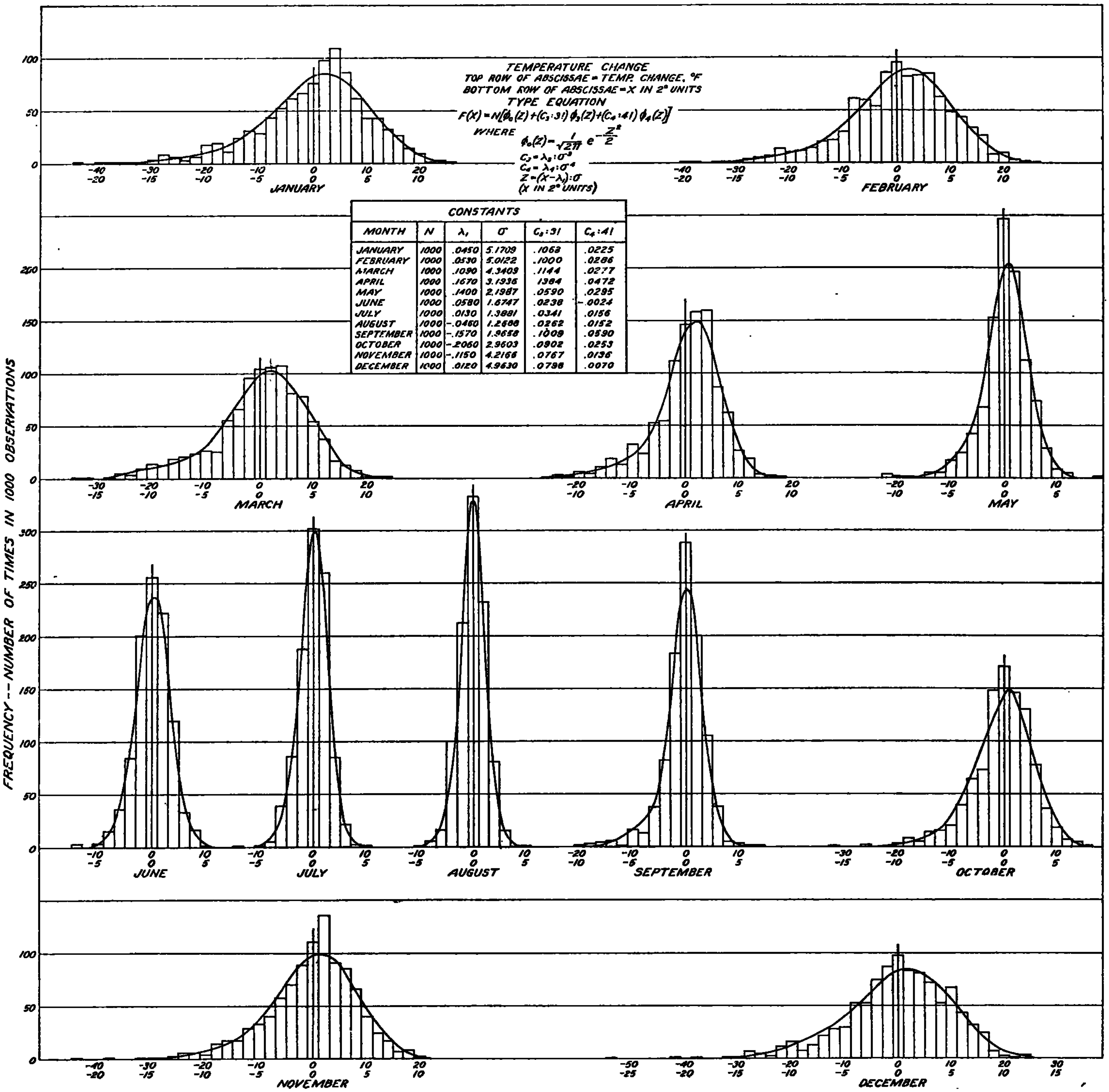
[1] Fisher, Arne, Mathematical Theory of Probabilities, New York, 1923.

[2] Jørgensen, N. R., Undersøgelser over Frequensflader og Korrelation, Copenhagen, 1916.

than five observations were neglected, it appears that there can be no serious objection to such a procedure.

Table 2 shows, by months, the probability of a. m. temperature changes exceeding the stationary limits used in the verification of forecasts. The small chance of a temperature change exceeding 6° in the summer months is noteworthy. In August both the observed frequency and the calculated frequency of such changes amount to only 8 in 1,000.

Figure 1 shows the observed distribution and the Gram-Charlier curves of best fit, as well as the type equation, and all the constants. An interesting feature is the persistent negative skewness, even in those months when the annual march of temperature is downward. This nega-



CONSTANTS					
MONTH	N	λ_1	σ	$C_3 : 3!$	$C_4 : 4!$
JANUARY	1000	.0450	5.1709	.1063	.0225
FEBRUARY	1000	.0530	5.0122	.1000	.0286
MARCH	1000	.1090	4.3409	.1144	.0277
APRIL	1000	.1670	3.1936	1384	.0472
MAY	1000	.1400	2.1987	.0590	.0295
JUNE	1000	.0580	1.6747	.0238	-.0024
JULY	1000	.0130	1.3881	.0341	.0156
AUGUST	1000	-.0460	1.2688	.0262	.0152
SEPTEMBER	1000	-.1570	1.9658	.1009	.0590
OCTOBER	1000	-.2060	2.9603	.0902	.0253
NOVEMBER	1000	-.1150	4.2166	.0767	.0136
DECEMBER	1000	.0120	4.9630	.0798	.0070

FIG. 1

tive skewness seems to be due, at least in part, to the steep temperature gradient in advance of passing HIGHS, giving rise to sudden and sharp falls in temperature, after which the rise is more gradual.

TABLE 1.—(A) *Computation of parameters, January*

Temperature change	X	F(X)	XF(X)	X^2	$X^2F(X)$	X^3	$X^3F(X)$	X^4	$X^4F(X)$	$(X+1)^4$	$(X+1)^4F(X)$
−44	−22	1	−22	484	484	−10,648	−10,648	234,256	234,256	194,481	194,481
−42	−21	0	0	441	0	−9,261	0	194,481	0	160,000	0
−40	−20	1	−20	400	400	−8,000	−8,000	160,000	160,000	130,321	130,321
−38	−19	1	−19	361	361	−6,859	−6,859	130,321	130,321	104,976	104,976
−36	−18	1	−18	324	324	−5,832	−5,832	104,976	104,976	83,521	83,521
−34	−17	1	−17	289	289	−4,913	−4,913	83,521	83,521	65,536	65,536
−32	−16	1	−16	256	256	−4,096	−4,096	65,536	65,536	50,625	50,625
−30	−15	4	−60	225	900	−3,375	−13,500	50,625	202,500	38,416	153,664
−28	−14	9	−126	196	1,764	−2,744	−24,696	38,416	345,744	28,561	257,049
−26	−13	7	−91	169	1,183	−2,197	−15,379	28,561	199,927	20,736	145,152
−24	−12	3	−36	144	432	−1,728	−5,184	20,736	62,208	14,641	43,923
−22	−11	7	−77	121	847	−1,331	−9,317	14,641	102,487	10,000	70,000
−20	−10	18	−180	100	1,800	−1,000	−18,000	10,000	180,000	6,561	118,098
−18	−9	19	−171	81	1,539	−729	−13,857	6,561	124,659	4,096	77,824
−16	−8	11	−88	64	704	−512	−5,632	4,096	45,056	2,401	26,411
−14	−7	24	−168	49	1,176	−343	−8,232	2,401	57,624	1,296	31,104
−12	−6	31	−186	36	1,116	−216	−6,696	1,296	40,176	625	19,375
−10	−5	29	−145	25	725	−125	−3,625	625	18,125	256	7,424
−8	−4	44	−176	16	704	−64	−2,816	256	11,264	81	3,564
−6	−3	53	−159	9	477	−27	−1,431	81	4,293	16	848
−4	−2	62	−124	4	248	−8	−496	16	992	1	62
−2	−1	67	−67	1	67	−1	−67	1	67	0	0
0	0	77	0	0	0	0	0	0	0	1	77
2	1	98	98	1	98	1	98	1	98	16	1,568
4	2	110	220	4	441	8	880	16	1,760	81	8,910
6	3	87	261	9	783	27	2,349	81	7,047	256	22,272
8	4	61	244	16	976	64	3,904	256	15,616	625	38,125
10	5	43	215	25	1,075	125	5,375	625	26,875	1,296	55,728
12	6	43	258	36	1,548	216	9,288	1,296	55,728	2,401	103,243
14	7	32	224	49	1,568	343	10,976	2,401	76,832	4,096	131,072
16	8	26	208	64	1,664	512	13,312	4,096	106,496	6,561	170,586
18	9	15	135	81	1,215	729	10,935	6,561	98,415	10,000	150,000
20	10	10	100	100	1,000	1,000	10,000	10,000	100,000	14,641	146,410
22	11	1	11	121	121	1,331	1,331	14,641	14,641	20,736	20,736
24	12	2	24	144	288	1,728	3,456	20,736	41,472	28,561	57,122
26	13	1	13	169	169	2,197	2,197	28,561	28,561	38,416	38,416
Σ			−1,966 2,011				−169,270 74,101				
s_r			45		26,741		−95,169		2,747,273		2,528,223
m_r			.045		26.741		−95.169		2,797.273		
Adjusted s_r							−84,521		2,513,017		
Adjusted m_r							−84.6056		2,515.5326		

$\lambda_1 = m_1 = .0450$ $\quad m_2 = 26.7410$ $\quad s_4 = 2,747,273$

$\lambda_1^2 = m_1^2 = .0020$ $\quad -m_1^2 = .0020$ $\quad 4s_3 = -330,676$

$\lambda_1^3 = m_1^3 = .0001$ $\quad \lambda_2 = 26.7390 = \sigma^2$ $\quad 6s_2 = 160,446$

$\lambda_1^4 = m_1^4 = .0000$ $\quad \sqrt{\lambda_2} = 5.1709 = \sigma$ $\quad 4s_1 = 180$

$138.27 = \sigma^3$ $\quad s_0 = 1,000$

$714.95 = \sigma^4$ $\quad$ Check $= 2,528,223$

$m_2m_1 = 1.2033$ $\quad m_3m_1 = -3.8073$ $\quad m_2^2 = 715.09$ $\quad m_2m_1^2 = .0535$

$m_3 = -84.6056$ $\quad m_4 = 2,515.5326$ $\quad \lambda_4 = 386.1338$

$-3m_2m_1 = -3.6099$ $\quad -4m_3m_1 = 15.2292$ $\quad 4m_1\lambda_3 = -15.8788$

$2m_1^3 = .0002$ $\quad -3m_2^2 = -2,145.2700$ $\quad 6m_1^2\lambda_2 = .3209$

$\lambda_3 = -88.2153$ $\quad 12m_2m_1^2 = .6420$ $\quad 3\lambda_2^2 = 2,144.8500$

$-6m_1^4 = .0000$ $\quad m_1^4 = .0000$

$\lambda_4 = 386.1338$ $\quad$ Check $= 2,515.4259 = m_4$

$c_3 = \lambda_3 : \sigma^3 = -.6380$ $\quad c_4 = \lambda_4 : \sigma^4 = .5401$

$-c_3 : 3! = .1063$ $\quad c_4 : 4! = .0225$

TABLE 1.—(B) *Solution, January*

X	$X-\lambda_1$	$\frac{(x-\lambda_1)}{\sigma}$	$\phi_0(Z)$	$\phi_3(Z)$	$\phi_4(Z)$	7	8	9	10	11
−23	−23.045	−4.457	0.0000	0.0018	0.0062	0.0002	0.0001	0.0003	0	0
−22	−22.045	−4.263	.0001	.0048	.0150	.0005	.0003	.0009	0	1
−21	−21.045	−4.070	.0001	.0069	.0205	.0007	.0005	.0013	0	0
−20	−20.045	−3.877	.0002	.0100	.0300	.0011	.0007	.0020	0	1
−19	−19.045	−3.683	.0005	.0177	.0481	.0019	.0011	.0035	1	1
−18	−18.045	−3.490	.0009	.0290	.0707	.0031	.0016	.0056	1	1
−17	−17.045	−3.296	.0017	.0452	.0980	.0048	.0022	.0087	2	1
−16	−16.045	−3.103	.0032	.0665	.1228	.0071	.0028	.0131	3	1
−15	−15.045	−2.910	.0058	.0920	.1382	.0098	.0031	.0187	4	4
−14	−14.045	−2.716	.0100	.1186	.1312	.0126	.0030	.0256	5	9
−13	−13.045	−2.523	.0166	.1404	.0882	.0149	.0020	.0335	6	7
−12	−12.045	−2.330	.0264	.1496	−.0027	.0159	−.0001	.0422	8	3
−11	−11.045	−2.123	.0419	.1335	−.1562	.0142	−.0035	.0526	10	7
−10	−10.045	−1.943	.0605	.0909	−.3261	.0097	−.0073	.0629	12	18
−9	−9.045	−1.749	.0864	−.0087	−.5272	−.0009	−.0119	.0736	14	19
−8	−8.045	−1.556	.1190	−.1071	−.6736	−.0114	−.0152	.0924	18	11
−7	−7.045	−1.363	.1575	−.2453	−.7398	−.0261	−.0166	.1148	22	24
−6	−6.045	−1.169	.2015	−.3933	−.6622	−.0418	−.0149	.1448	28	31
−5	−5.045	−.976	.2478	−.4965	−.4631	−.0528	−.0104	.1846	36	29
−4	−4.045	−.782	.2939	−.5488	−.0864	−.0583	−.0019	.2337	45	44
−3	−3.045	−.589	.3354	−.5240	.3661	−.0557	.0082	.2879	56	53
−2	−2.045	−.395	.3690	−.4144	.7896	−.0441	.0178	.3427	66	62
−1	−1.045	−.202	.3909	−.2335	1.0776	−.0248	.0242	.3903	76	67
0	−.045	−.009	.3989	−.0107	1.1965	−.0011	.0262	.4240	82	77
1	.955	.185	.3922	.2142	1.0963	.0228	.0247	.4397	85	98
2	1.955	.378	.3714	.3987	.8086	.0424	.0182	.4320	83	110
3	2.955	.571	.3389	.5175	.3901	.0550	.0088	.4027	78	87
4	3.955	.765	.2978	.5499	−.0503	.0585	−.0011	.3552	69	61
5	4.955	.958	.2511	.5029	−.4195	.0535	−.0094	.2952	57	43
6	5.955	1.152	.2054	.3959	−.6557	.0421	−.0148	.2327	45	43
7	6.955	1.345	.1614	.2586	−.7397	.0275	−.0166	.1723	33	32
8	7.955	1.538	.1222	.1193	−.6843	.0127	−.0154	.1195	23	26
9	8.955	1.732	.0890	.0000	−.5341	.0000	−.0120	.0770	15	15
10	9.955	1.925	.0625	−.0849	−.3441	−.0090	−.0077	.0458	9	10
11	10.955	2.126	.0416	−.1344	−.1536	−.0143	−.0035	.0238	5	1
12	11.955	2.319	.0271	−.1494	−.0092	−.0159	−.0002	.0110	2	2
13	12.955	2.513	.0169	−.1413	.0945	−.0151	.0019	.0037	1	1
14	13.955	2.706	.0102	−.1201	.1299	−.0128	.0029	.0003	0	0
Σ								5.1706	1,000	1,000

TABLE 2.—*The probability of temperature changes (7 a. m. to 7 a. m.) at Montgomery, Ala.*

Month	Stationary limit	Exceeding stationary limit						Within stationary limit	
		Rise		Fall		Combined			
		Actual	Theoretical	Actual	Theoretical	Actual	Theoretical	Actual	Theoretical
January	10	13.0	13.3	13.9	13.4	26.9	26.7	73.1	73.3
February	10	12.8	12.2	12.1	12.5	24.9	24.7	75.1	75.3
March	10	7.9	8.9	11.3	10.3	19.2	19.2	80.8	80.8
April	8	5.1	5.6	9.2	8.6	14.3	14.2	85.7	85.8
May	8	1.5	1.6	3.2	3.0	4.7	4.6	95.3	95.4
June	6	2.0	1.5	2.4	2.0	4.4	3.5	95.6	96.5
July	6	.5	.4	.7	1.0	1.2	1.4	98.8	98.6
August	6	.1	.2	.7	.6	.8	.8	99.2	99.2
September	6	1.2	1.6	4.9	6.0	6.1	7.6	93.9	92.4
October	8	3.3	3.8	7.5	8.2	10.8	12.0	89.2	88.0
November	8	10.6	12.7	14.1	14.4	24.7	27.1	75.3	72.9
December	10	12.1	12.8	12.3	13.4	24.4	26.2	75.6	73.8
Sums		70.1	74.6	92.3	93.4	162.4	168.0	1,037.6	1,032.0
Means		5.8	6.2	7.7	7.8	13.5	14.0	86.5	86.0